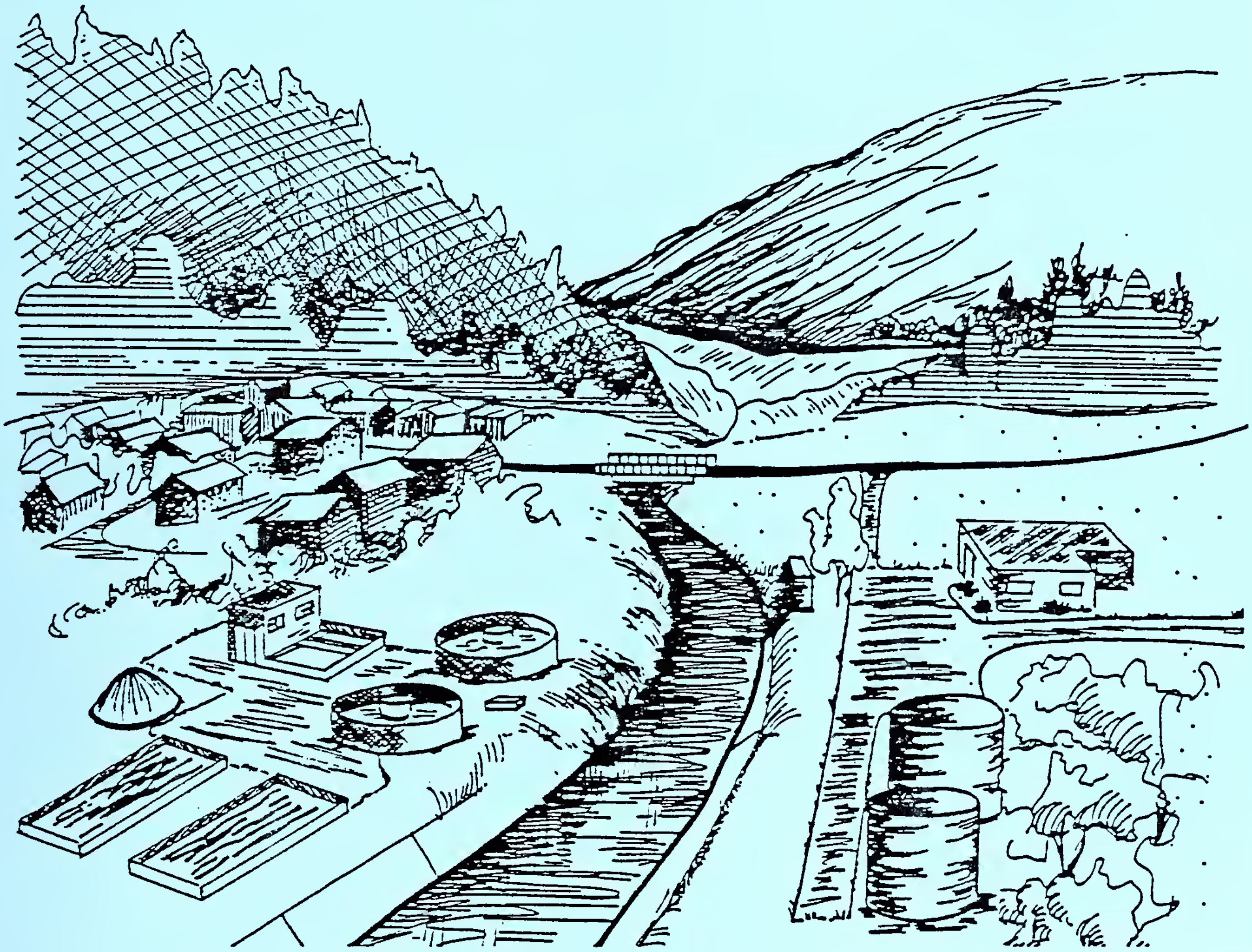
INFRASTRUCTURE STUDIES

A GUIDEBOOK FOR WATER SUPPLY SYSTEM OPERATORS



SUSQUEHANNA RIVER BASIN COMMISSION
SEPTEMBER 1988

The Susquehanna River Basin Commission was created as an independent agency by a Federal-Interstate Compact* among the States of Maryland, New York, Commonwealth of Pennsylvania and the Federal Government. In creating the Commission, the Congress and State Legislatures formally recognized the water resources of the Susquehanna River basin as a regional asset vested with local, State and National interests for which all the parties share responsibility. As the single Federal-Interstate water resources agency with basinwide authority, the Commission's goal is to effect coordinated planning, conservation, management, utilization, development and control of basin water resources among the government and private sectors.

* Statutory Citations: Federal - Pub. L. 91-575, 84 Stat. 1509 (December, 1970); Maryland - Natural Resources §8-301 (Michie 1974); New York - ECL §21-1301 (McKinney 1973); and Pennsylvania - 32 P.S. 820.1 (Supp. 1976).

SUSQUEHANNA RIVER BASIN COMMISSION
Robert J. Bielo
Executive Director

INFRASTRUCTURE STUDIES
A GUIDEBOOK FOR WATER SUPPLY SYSTEM OPERATORS

Prepared By:

Edmond E. Seay
Staff Economist

and

Donald R. Jackson
Staff Hydrologist

Additional Copies May Be Obtained by Contacting:

Susquehanna River Basin Commission
1721 N. Front St.
Harrisburg, PA 17102
Telephone: (717) 238-0423

Publication No. 119

Table of Contents

ACKNOWLEDGMENTS

We wish to thank the many persons who have reviewed and commented on several drafts of the guidebook. We are particularly indebted to staff members of the Maryland Department of Natural Resources, the New York Department of Environmental Conservation, the Pennsylvania Department of Environmental Resources, the Pennsylvania Public Utilities Commission, and the American Water Works Association. The Guidebook has been improved substantially by the many useful suggestions we received. Although we could not incorporate every suggestion, we are grateful to everyone who took the time to review the document and send us comments.

PART I

INTRODUCTION

The term "infrastructure" generally refers to the physical facilities that support a community. For instance, paved roads, bridges, school buildings, waste treatment systems, and water supply systems all are a part of the infrastructure of a city or region.

Great concern exists that the nation's infrastructure has been allowed to deteriorate, especially in the older cities in the northeastern United States. Many communities in the Susquehanna River Basin have facilities that need repair or replacement. All infrastructure requires periodic inspection and maintainance. Since the Susquehanna River Basin Commission's (SRBC) primary concern is water resources, this guidebook focuses only on water supply systems.

There are about 570 public water supply systems within the Susquehanna River Basin. The vast majority of these have fewer than 1,000 customer connections. State, regional and Federal water resource management agencies are very concerned whether these systems make routine inspections and timely repairs. In order to identify problems within the systems, develop cost-effective programs for repairs or other improvements, and to conserve materials, manpower and natural resources, water supply system operators are urged to undertake infrastructure studies.

First, the system operator must decide who will conduct the study. If technical expertise is available on their staff, water supply system operators may carry out part or all of a study

without outside help. Many consulting engineering firms, however, can perform infrastructure studies, and some specialize in them.[1] As noted in Part V, technical assistance is also available from various Federal and state agencies.

The primary result of comprehensive studies are long-term cost savings to the system. Savings arise in a number of different ways. Leak detection and repair programs can reduce treatment costs, increase revenues, and defer expansion of sources of supply and/or treatment facilities. Installing meters through the entire system and a regular meter maintenance program will improve system management capability and can also increase revenues. Infrastructure studies can help to determine whether components of the distribution system need to be rehabilitated or replaced, and which is more desirable.

---

[1] The August, 1986 issue of the AWWA publication, OpFlow, has a useful article on guidelines for selecting a consulting engineer. The article is reprinted as Appendix I.

PURPOSE AND SCOPE OF GUIDEBOOK

The quality and cost of an infrastructure study depend directly on the quality and quantity of information available about the system. If the information and the budget are limited, a study can only be carried out using available data plus "rules of thumb" and industry averages. Such studies, however, sacrifice a great deal of accuracy, and may even produce misleading conclusions.

One purpose of this publication is to identify what information is needed about each component of water supply utility operations--source, transmission, storage, treatment, distribution, and finances--to make the study as accurate and cost-effective as possible. If a consultant conducts a study of the system, it is more cost-effective for the utility staff to collect routine or readily available information, instead of paying the consultant for that work. Certain analyses need long-term information, and without historical records, the quality of the study will suffer.

The guidebook includes a preliminary, self-rating survey of water systems, and descriptions of types of infrastructure studies commonly performed together with their data requirements. It offers advice on locating outside assistance and lists agencies concerned with water supply systems. Also included are examples of record keeping forms and a list of articles for further reading about various aspects of system management.

PART II

A PRELIMINARY SURVEY

Many plant managers are so busy with day-to-day operations there is little time to survey their system for potential problems. The following self-rating survey (pages 5-6) will help identify potential problems. It provides a quick review of the various system components and suggests which areas may need attention.

For those who might wish to make a more intensive survey of their system, the American Water Works Association (AWWA) has published a very useful workbook. Titled Water Resources Audit - A Workbook for Small Communities, the publication provides an overview of the community's water resources, identifies problem areas, sets goals, and builds strategies to meet these goals. The audit is developed from data compiled in work sheets that come with the book. Most of the data can be gathered by employees from system and other community records, consultant reports, and governmental agencies. The publication is available from:

AWWA
Customer Service Dept.
6666 West Quincy Avenue
Denver, CO 80235
(303) 794-7711

There is a charge for the workbook.

To follow up on survey findings, refer to Part III of the guidebook where the various types of studies and their data requirements are discussed.

Quick Survey for Water System Managers & Operators

	Yes/No	Probable Causes
1. Source Problems		
a. Do your existing sources ever go dry?	____	Inadequate source.
b. If your existing source is wells, is the water level in the well decreasing over the long term?	____	Pumping too much water from aquifer.
c. If your existing source is wells, has the yield decreased dramatically?	____	Incrustation or clogging of well; interference from nearby wells; pump in poor condition.
2. Quantity Problems		
a. Do you have frequent water main breaks in the same or nearby pipes?	____	Corrosion; poor construction; improper tapping; loss of support; excessive loads; freezing; water hammer.
b. Do your tests of hydrant pressures show pressures less than 30 psi (residual)?	____	Inadequate distribution piping, pumping, or storage capacity/elevation.
c. Do your records show more than 15% difference between production and billed amounts?	____	Leakage; excessive unmetered uses; customer meter under registration; master meter over registration; unauthorized connections.
d. Have you had to curtail water use any time during the past ten years?	____	Inadequate source; main breaks; insufficient storage or treatment capacity.
e. Do equipment breakdowns occur more frequently than five years ago?	____	Inadequate maintenance; some equipment may need replacing.
f. Do customers or the fire company complain about low pressure or insufficient water either during normal operation or during fires?	____	Inadequate size mains; inadequate pumping or storage capacity/elevation; excessive demand during high use seasons and stress periods.

	Yes/No	Probable Causes
3. Quality Problems		
a. Do you have to flush mains more often than once per year?	____	Source quality; inadequate treatment; corrosion; deposition; sedimentation.
b. Has your system been cited by a state agency for violation of drinking water quality standards within past five years?	____	Source quality; inadequate treatment.
c. Do customers complain about:		
- Tastes and odors?	____	Source quality; inadequate treatment; bacteria in distribution system.
- Color in the water?	____	Source quality; distribution system corrosion; inadequate treatment.
- Turbidity?	____	Source quality; inadequate treatment; distribution system sedimentation.
- Discolored laundry?	____	Distribution system corrosion or deposition; aggressive water; bacteria in distribution system.
- "Red water"?	____	Distribution system corrosion; aggressive water; bacteria in distribution system.
d. Are quantities of chemicals used increasing?	____	Raw water quality deteriorating; process or equipment changes needed; employees using excessive amounts.
4. Revenue Problems		
a. Are system revenues inadequate to permit necessary maintenance?	____	Need to increase rates or reduce cost of service.

PART III

TYPES OF INFRASTRUCTURE STUDIES

Several different types of studies can be carried out. Some can be performed by water utility personnel while others require the services of consultants. Brief descriptions of a few of the possible studies are given below.

1. Adequacy of Source

A water source adequate to meet present needs and allow for future growth in system demand is desirable. Regardless of whether the system depends upon surface or ground-water sources, or a combination of both, analyses of the source(s) can provide information about the following points:

(a) The adequacy of existing supplies: How well does the present supply meet all system needs, such as average day, peak hour, peak day, and fire flows?

(b) The rate of increase in demand: At what point in the future will additional sources or increased system capacity be needed?

(c) Help in isolating causes of water quality problems: What conditions at the source or in the system may lower the quality of the water at the customer's faucet?

The analyses also may suggest ways to deal with any deficiencies found. For example, if the source is adequate to meet average and peak day demands, but inadequate to meet peak hour or fire flow demands, increased distribution storage, e.g.,

tanks, may be the best solution. However, if peak day demands cannot be met, then standby sources such as wells may be a better solution.

2. Treatment Facilities

Careful management of the treatment facility can produce substantial benefits. Various analyses are possible, including those that do the following:

(a) Assess the adequacy of the existing treatment facility to meet future demands.

(b) Seek ways to reduce treatment costs via reduced labor, energy, or chemical costs.

(c) Determine means of upgrading the finished water to overcome quality problems.

(d) Make cost-effective "repair vs. replacement" decisions for equipment and machinery used in the treatment system.

(e) Reduce corrosion of the distribution system that reduces pressures and flow rates, and causes quality problems at the customer's tap.

3. Unaccounted-For Water

Water systems experiencing large differences between the quantity of water treated and the quantity billed may have any one of several problems. Frequently, programs that help find the source of the discrepancy will pay for themselves over time. The

goals of programs for reducing unaccounted-for water may include:

(a) Locating breaks in mains and service lines.

(b) Reducing treatment costs through treating less water, thus decreasing the amount of energy and chemicals used in the water treatment process.

(c) Identifying unrecorded connections, thereby increasing revenues through accounting for all uses.

(d) Deferring expansion of treatment facilities by delivering a larger proportion of the treated water to customers.

The analyses depend primarily on:

(a) Accurate master and customer meters. Generally this means instituting a program of regularly checking the accuracy of all meters in use.

(b) Frequent comparisons of the quantity of water produced with quantity delivered. This assumes that the information needed to make the comparisons is readily available, which is not always the case. In many plants, however, the necessary information can be compiled by adjusting the plant's system of record keeping.

(c) Accurate maps of the system giving the location of all main valves, hydrants, service lines and curb stops.

A leak detection program, carried out on a regular basis, can contribute significantly to reducing levels of unaccounted-for water. Several articles in Part VI, based on actual case

studies, describe the savings possible from leak detection and meter replacement programs.

4. Distribution System Analyses

The general condition of the valves and mains making up the distribution system can affect flow rates and pressures in the system. Methods for determining the condition of the distribution system are called "hydraulic analyses." Two types of hydraulic analyses can be made. The first utilizes actual measurements of the system in operation. The second involves developing a mathematical model of the system, and using a limited number of system measurements for model calibration.

a. Analyses Based on System Measurement

Many utilities measure hydrant pressures and flow rates as part of the regular flushing of the distribution system.[2] These readings show whether low pressures exist at locations where the measurements are made with the demand occurring at that time. If readings are taken at a large number of hydrants, the adequacy of system pressures can be determined. Hydrant pressure measurements can also be used to compute the flow rate available for fire fighting, to compare with fire flow standards set by the Insurance Services Office. If the computed flow rates under fire flow conditions are too low, fire insurance rates for the community may be higher than need be.

---

[2] AWWA has a computer program for sale that analyzes hydrant flow tests. It operates on IBM-PC compatible computers. (See Part VI, p. 35 for program reference.) As the cost of personal computers decline, even smaller water supply companies can consider using them.

Other measurements can be made of the system that require more equipment and skill than the hydrant pressure measurements. While utility personnel, with suitable training, can make these measurements, it may be desirable to hire consultants who have expertise in this area. Possible measurements include the diameter and cross-sectional area of a pipe as well as the velocity of flow through the pipe. The velocities are used to compute Hazen-Williams roughness coefficients (C factors) and flow rates. The pipe diameter, C factors, and velocities can be used together to determine the hydraulic capacity of the pipe and whether it has been reduced. Velocity measurements also can reveal whether valves are closed and flow rate data can help locate leaks or unauthorized usage.

b. Analyses Based on Mathematical Models

A mathematical model of the system provides a more complete picture of system operations and problems than either hydrant pressure measurements or measurements made in selected pipe segments. There are several computer programs which incorporate such mathematical models, but they are complex and some are proprietary. Therefore, many utilities will need to hire outside help to utilize these programs. The quality and quantity of the data used to run the model are crucial to the results. Clearly, the better the data, the more useful the results will be in determining the need for and establishing the costs and priorities for system improvements. The operator can save expensive consultant's time if he knows which data to make available to the consultant. A model can be used to determine

whether C factors are too low, if pumps are functioning properly, and the locationleaks and of valves which are partially or completely closed. Finally, a model is also useful in determining the adequacy of fire flows.

5. Replace or Repair Decisions

Frequently decisions to replace mains in a system are based solely on the age of the main. Studies of actual systems have shown that age alone is not the best predictor of when a main should be replaced. Break repair records for the system provide a much better guide to whether a main should be replaced or rehabilitated. Generally, cleaning and lining of basically sound mains will cost substantially less than replacement. (One study found that the average cost of replacing 4" mains with 8" was about $34 per foot. Using one estimating formula, cleaning and relining 4" and 8" mains costs about $14 and $17 per foot respectively. It should be remembered that costs both increase over time and vary according to local conditions. Thus, the dollar amounts mentioned here are intended to illustrate the potential cost differences between replacement and rehabilitation.)

Procedures have been developed to determine whether rehabilitation or replacement is more cost-effective. These procedures require fairly detailed leak and break records as described in the data needs section. Generally, additional record keeping is well worth the effort since it makes possible either low-cost repairs or replacements on a planned schedule which can be budgeted for in advance.

6. System Rates and Finances

To a large degree the availability of funds determine the ability of a water supply system to make needed replacements and repairs, improvements, and expansions. For many small municipally-owned water companies, it is common for all revenues to be deposited to the municipality's general fund, and only current operating expenses may be covered by the budget approved for the utility. Such an approach is short-sighted and frequently results in deferring needed maintenance until serious deterioration of the system has occurred.

Revenues, rate structures, bonding capacity and debt amortization capability are interrelated and can be analyzed. Budgets can be reviewed and adjusted to include adequate funding for routine maintenance and repairs. Leak detection programs and other efforts to reduce unaccounted-for water often pay for themselves. Under some circumstances such undertakings may even lead to increases in revenues.

Rate schedules should be analyzed for their revenue-producing capability, equity of costs among and within different categories of users, and impact on the quantity of water used by different users. Many of these studies can be made by the water company staff and some may require the use of consultants.

Major rehabilitation, replacement, or expansion of water supply system components frequently require substantial capital expenditures. Sources of capital have changed dramatically in the last few years. Grants from federal and regional development agencies are no longer common. New ways to finance major

infrastructure projects have been developed by both the private sector and state governments to partially offset the loss of grant funds. Some systems are undertaking major self-help efforts, utilizing local expertise, volunteers and the utility's own labor force to reduce construction costs.

Sources of financial and technical assistance are listed in Part V.

PART IV

INFRASTRUCTURE STUDY DATA NEEDS

Usually an infrastructure study focuses on the major components--source, treatment, distribution-- of a water supply system. In the following pages check lists of the information needed for studies of each system component are given. Where possible, the lists distinguish between essential and optional data. The essential data are necessary to make the analysis, while optional data improve the quality of the study. Essential data needs are marked with an asterisk (*).

Analyses of Water Supply Sources
Check List of Necessary Information

Reservoirs:

__________ *Location, usable capacity, area of protected watershed, total drainage area.

__________ *Reservoir storage curves and historical drought data.

__________ Results of any surveys to establish amount of sedimentation.

__________ Results of tests of raw water quality.

Streams:

__________ *Location, drainage area, and dependable yield.

Ground-Water Sources:

__________ *Map showing location of production well(s), monitoring well(s), and area of protected watershed.

__________ *Pump test results for production well(s); ground-water levels in monitoring well(s) during test. Records of weekly water level readings in monitoring well(s).

__________ Raw water quality test results.

All Sources:

__________ *Map or diagram of size, age, material, including storage tanks or receiving reservoirs in system.

__________ Repair history, inspection results of conveyance system from source to treatment facility,

__________ Engineering data for any pumps used in the source-to-treatment conveyance system. Certain engineering data is essential. Frequently it can be obtained from the equipment manufacturer.

Analyses of Treatment Facilities
Check List of Necessary Information

____________ *Engineering drawings of facility, showing location, size and capacity of each component.

____________ Inventory of components: Manufacturer, rated capacity, tested capacity, date of installation of each component.

____________ System failures: Records of the maintenance, repair, and replacement history of treatment plant components.

____________ *Records relating to any shutdowns: Date, cause, duration, corrective actions taken.

____________ *Records of chemical and biological testing of finished water samples.

Accounting for inputs: Using the most recent available information about the system, an itemization of:

____________ Quantity of raw water processed.

____________ Quantity and costs of chemicals used.

____________ Quantity and costs of energy used.

____________ Cost of labor (including supervision and management).

Analysis of Distribution System
Check List of Necessary Information

- ____________ *Detailed system maps showing the entire distribution system including the location, elevation (or ground elevation), size and type of all mains, valves, hydrants, pumping stations and storage tanks, date of installation, and location of all service connections and curb stops.
- ____________ A listing of all connections showing use, type, location and size. (Ideally these records exist as computer files or in computer readable form.)
- ____________ A listing of the total length of each size main in the system.
- ____________ *Recent hydrant pressure flow measurements, including date and time at which measurements were made.
- ____________ *Boundaries of pressure districts.
- ____________ *Location and operating characteristics of check valves and pressure reducing valves.
- ____________ Pipe diameter, headloss and flow rate measurements made in the pipe.
- ____________ *Pump flow rate and tank elevation charts for dates on which hydrant pressure or in-pipe measurements were made.
- ____________ Water use, flow rate and pressure data under controlled conditions.
- ____________ Periodic night time flow reading.
- ____________ Flow distribution or distribution of water use among pressure districts.
- ____________ Location and water use of larger customers.

For all pumps associated with the water distribution system, the following material should be assembled:

- ____________ *Pump characteristic curves, impeller sizes and operating schedules.
- ____________ The results of any tests made to confirm the accuracy of the curves.
- ____________ The maintenance and repair history for each.

____________ *Piping configuration for pump station(s).

____________ *Elevation of centerline of pumps.

____________ "Normal" flow rates and suction and discharge pressures.

____________ Records of any component failures: dates, causes, actions taken, costs.

Finished water storage:

____________ *Elevation, capacity, normal operating level and operating schedule for all tanks.

____________ Description of any overflow detection or prevention system connected to the storage system.

Maintenance and repair history:

____________ Main breaks - Location, date, probable cause.

____________ Valve inspection - Dates, conditions found.

Leak Detection Program

____________ Type(Sonic or flow rates); frequency; findings.

____________ Comparison of findings with break repair records (to establish accuracy of detection program).

____________ Comparison of findings with estimate of unaccounted-for water.

PART V

LOCATING OUTSIDE ASSISTANCE

1. Technical Assistance Overview

Numerous agencies, organizations, and firms can either perform all or portions of water supply system analyses or direct system operators to those who can.

The American Water Works Association (AWWA) is an excellent source of technical information about many facets of water supply system operation and management. Their monthly publication, OpFlow, is a useful magazine for operators. Two other publications, Public Works, a monthly industry journal, and Civil Engineering, published monthly by the American Society of Civil Engineers, both carry articles on water distribution system operation and maintenance.

The Maryland Departments of Natural Resources and the Environment, the New York Departments of Environmental Conservation and Health, and the Pennsylvania Department of Environmental Resources can provide, to varying degrees, technical assistance or guidance in conducting the various studies. See the section below for details.

Both New York and Pennsylvania have Rural Water Associations that assist water supply systems in communities of less than 10,000 population. The associations are state affiliates of the National Rural Water Association.

The associations offer, at no charge, the following services:

1. On-site, hands-on technical assistance.
2. Training sessions for all personnel.
3. Operation and management publications.
4. Liaison with Federal and state agencies.
5. Loan of training films and slide sets.

Staff of the Susquehanna River Basin Commission can provide guidance on study techniques, furnish examples of useful record keeping formats, and help locate possible sources of assistance.

2. Technical Assistance Contacts

For Water Supply systems located in all parts of the Basin:

A. American Water Works Association
6666 West Quincy Avenue
Denver, CO 80235
Telephone: (303)794-7711

For referrals to literature on a particular topic, contact **AWWA Information Services** at the address shown above.
For a catalog of publications or to order publications, contact **AWWA Computer Services** at the address shown above.

B. Planning & Operations Division
Susquehanna River Basin Commission
1721 N. Front Street
Harrisburg, PA 17102-2391
Telephone: (717)238-0425

For Water Supply systems located in Maryland:

The Maryland Department of Natural Resources (MDNR) and the Maryland Department of the Environment (MDE) can provide guidance or technical assistance in conducting various studies. The MDNR, which is responsible for the State's water supply resources, performs or supervises multiple purpose development, management and conservation plans. The MDE monitors the adequacy, safety and reliability of the State's water supply systems.

The Water Supply Resources Division of MDNR offers a leak detection program, including equipment and operators, to qualifying small and medium size utilities for pipe location and leak detection. The utilities will receive reports detailing the leaks detected. In turn they must commit themselves to making timely repairs of any leaks. They must also submit repair and water savings reports to the water conservation project manager.

For more information, contact:

A. Water Supply Resource Division
Water Resources Administration
Deptpartment of Natural Resources
Tawes State Office Building (D-3)
Annapolis, MD 21401
Telephone: (301) 974-3675

B. Water Supply Program
Department of the Environment
201 West Preston Street
Baltimore, MD 21201
Telephone: (301)225-6361

For Water Supply systems located in New York:

The Department of Environmental Conservation administers the Water Supply permit program. In general, permits are required for the installation of a new or expansion of an existing community water supply system, as well as acquisition of new or additional sources of water for new or existing water supply systems. DEC has broad management responsibilities over the natural water resources of the state.

The Department of Health oversees the management of water systems from the raw water intake through the finished product. They exercise this responsibility by setting and enforcing drinking water standards, inspecting water system components and operation, training and certifying plant operators, and reviewing and approving water system plans and specifications.

For assistance and guidance in dealing with problems related to water sources and water supply system operations, contact the regional office serving your county, or the Rural Water Association.

A. Department of Environmental Conservation
(Division of Regulatory Affairs)

Avon Office

6274 E. Avon-Lima Road
Avon, NY 14414
(716)226-2466

Counties Served: Chemung, Livingston, Schuyler, Steuben, Yates

Buffalo Office

600 Delaware Ave.
Buffalo, NY 14202
(716)847-4551

County Served: Allegany

Liverpool Office

7481 Henry Clay Blvd.
Liverpool, NY 13088
(315)428-4497

Counties Served: Broome, Chenango, Cortland, Madison, Onondaga, Tioga, Tompkins

Stamford Sub-Office

Route 10, Jefferson Road
Stamford, NY 12167
(607)652-7364

Counties Served: Delaware, Otsego, Schoharie

Utica Sub-Office

State Office Building
207 Genesee Street
Utica, NY 13501
(315)793-2555

Counties Served: Herkimer, Oneida

B. Department of Health

Albany Office

(518)457-7150

Counties Served: Delaware, Otsego, Scholarie

Buffalo Office

(716)847-4500

County Served: Allegany

Rochester Office

(716)423-8069

Counties Served: Schuyler, Steuben, Yates

Syracuse Office

(315)428-4726

Counties Served: Broome, Chemung, Chenango, Cortland, Herkimer, Madison, Oneida, Onondaga, Tioga, Tompkin

C. New York State Rural Water Association

401 State Street
Hudson, NY 12534
(518)828-5040

Greg Backus, Program Manager
Home Phone: (716)346-2601

George Flummer, Circuit Rider
Home Phone: (315)824-3659

For Water Supply systems located in Pennsylvania:

A. Department of Environmental Resources

1. Bureau of Water Resources Management's Technical Assistance Program

Free technical assistance to water supply systems serving less than 1,000 customers. Help given in decreasing unaccounted-for water, locating mains and services, establishing meter testing and replacement schedule, recommending source monitoring measures and developing operational drought response programs. The Water Conservation/Technical Assistance Section loans pipe locating and leak detection equipment and trains plant personnel in the proper use of the equipment. For more information, contact:

Pa. Dept. of Environmental Resources
Bureau of Water Resources Management
Water Conservation/Technical Assistance Section
P.O. Box 1467
Harrisburg, PA 17120
(717)787-5008

2. Bureau of Community Environmental Control

The regional office staffs can assist plant operators in determining the probable cause of water quality problems. Contact the regional office serving your county.

Harrisburg Regional Office

(717) 657-4585

Counties Served: Adams, Bedford, Blair, Cumberland, Dauphin, Huntingdon, Juniata, Lancaster, Lebanon, Mifflin, Perry, York.

Wilkes-Barre Regional Office

(717)826-2511

Counties Served: Lackawanna, Luzerne, Schuylkill, Susquehanna, Wayne, Wyoming

Williamsport Regional Office

(717)327-3636

Counties Served: Bradford, Cameron, Clearfield, Centre, Clinton, Columbia, Lycoming, Montour, Northumberland, Potter, Snyder, Sullivan, Tioga, Union

B. Pennsylvania Rural Water Association

P.O. Box 90
Saltsburg, PA 15681
(412)639-3246

Herb Pizer, Program Manager
Home Phone: (412)639-9866

Stephen M. Krchnavy, Circuit Rider
Home Phone: (412)226-8921

3. Financial Assistance Overview

A number of alternatives have been developed for financing water supply systems. Many of these focus on systems located in non-urban areas. In Pennsylvania, programs can be found in the Departments of Commerce and Community Affairs as well as the Pennsylvania Infrastructure Investment Authority, (PENNVEST). Similar programs come under the Environmental Facilities Corporation in New York. In Maryland several agencies oversee grant and loan programs. Addresses of the agencies to contact are given below.

Pa. DER's Water Conservation/Technical Assistance Section has prepared a very useful publication that gives a brief description of and the point of contact for the various Federal and state financial assistance programs. Titled "Financial Assistance for Pennsylvania Water Systems," the publication is available from the address given below.

4. <u>Financial Assistance Contacts</u>
(Grants, loans, bond sales)

Maryland:

Water Supply Program
Department of the Environment
201 West Preston St.
Baltimore, MD 21201
Telephone: (301) 225-6369

Maryland Environmental Service
2020 Industrial Drive
Annapolis, MD 21401
Telephone: (301) 974-7281

Dept of Housing and Community Development
45 Calvert Street
Annapolis, MD 21401

a. Small Cities Community Development
   Block Grant Program
   Coordinator: Ms. Tara Clifford
   (301) 974-2854

b. Infrastructure Financinc Bond Program:
   Community Development Administration
   Ms. Penelope Long
   (301) 974-3161

New York:

Environmental Facilities Corp.
Rm 538
50 Wolf Road
Albany, NY 12233
(518) 457-4222

NY State Self-Help Support Loan Fund
Office of Local Government Services
Department of State
162 Washington Avenue
Albany, NY 12231
(518) 473-3355

Pennsylvania: PA Dept. of Commerce
Community Facilities Program
Bureau of Business Financing
467 Forum Building
Harrisburg, PA 17120
Telephone: (717)787-7120

PA Dept. of Community Affairs
State Administered Community Devel-
opment Block Grant Program ("CDBG")
Bureau of Housing & Development
515 Forum Building
P.O. Box 155
Harrisburg, PA 17120
Telephone: (717)783-3910

PENNVEST
Pa. Infrastructure Investment Authority
P.O. Box 1344
Harrisburg, PA 17105
(717)787-8137

For copy of financial assistance publication:

Bureau of Water Resources Management
Water Conservation/Technical Assistance
Section
P.O. Box 1467
Harrisburg, PA 17120
Telephone: (717)787-5008

PART VI

USEFUL REFERENCES

A. System Analyses, Management and Rehabilitation

American Water Works Assoc., Introduction to Water Distribution, Vol. 3, AWWA, Denver, 1986.

The third volume in a five-part handbook series for use in a comprehensive training program for treatment plant and distribution system operators. Other volumes cover sources and transmission, treatment, and water quality analyses.

Corless, J. P., "Managing a Comprehensive Water Main Reconstruction Program", Jour. AWWA, 74:11 (Nov. 1982).

A comprehensive program for reconstructing the aging portions of the Washington Suburban Sanitary Commission's distribution system consists primarily of cleaning mains and lining them with mortar. This article describes how specific projects are selected, how the work is planned and managed, and how water service is maintained with the least amount of inconvenience to the public during the reconstruction process.

Daffer, R. A., "Conserving Energy In Water Systems", Jour. AWWA, 76:12 (Dec. 1984).

Discusses the importance of designing and operating water distribution systems, including system maintenance, to minimize energy costs.

Duncan, W. S., "Maintenance of Wells Includes Redevelopment", OpFlow, 11:11 (Nov. 1985).

Discusses the maintenance of wells and the determination of when a well should be redeveloped to increase its life and yield.

Franklin, B. W., "Maintaining Distribution System Valves and Fire Hydrants", Jour. AWWA, 74:11 (Nov. 1982).

Keeping water distribution system valves and fire hydrants serviceable at all times requires continuous attention. Based on recommended industry practices and standards, the preventive maintenance and system updating program at the St. Louis County Water Co. is described in detail.

Godfrey, K. A., "New Tools Help Find Flaws", Civil Engineering, 54:9 (Sept. 1984).

Describes new tools for detecting flaws in infrastructure, including use of acoustic methods to locate leaks in water distribution systems.

Hudson, W. D., "Increasing Water System Efficiency Through Control of Unaccounted-For Water", Jour. AWWA, 70:7 (July 1978).

Describes use of the metered ratio as a measure of water utility system efficiency, and describes how to locate and deal with sources of unaccounted-for water.

Jones, L. V., "Effective Cleaning of Water Mains", OpFlow, 11:3 (Mar. 1985).

Keller, C. W., "Analysis of Unaccounted-For Water", Jour. AWWA, 68:3 (Mar. 1976).

Keller, C. W., "Notes and Comments-Analysis of Unaccounted-For Water", Jour. AWWA, 69:3 (Mar. 1977).

Presents data on percent unaccounted-for water and average loss per mile of line for a large number of utilities. Discusses reasons and procedures for cleaning water mains in order to improve water quality at the tap.

Law, N. D., "Revenue Benefits Through Large Meter Maintenance", Jour. AWWA, 70:8 (Aug. 1978).

Discusses the increased revenue obtained through a systematic meter maintenance program.

Male, J. W., Noss, R. R. and Moore, I. C., Identifying and Reducing Losses in Water Distribution Systems, Noyes Publications, Park Ridge, N.J. (1986).

Provides guidelines for assessing problems associated with water distribution systems. Included are recommendations for determining water usage, estimating system losses, evaluating alternatives for system improvements, and calculating the benefits and costs involved.

"Meter Changeout Brings Water Losses Down, Revenue Up", Public Works (July, 1986).

A case study of one city's experience with replacing meters and the resulting net savings.

Moyer, E. E., _et al._, "The Economics of Leak Detection and Repair-A Case Study", _Jour. AWWA_, 75:1 (Jan. 1983).

Analyzes the costs and benefits of a leak detection and repair program for a publicly owned water utility. The characteristics of different types of leaks and the accuracy of the detection method used are also discussed. The results of the analysis demonstrate that benefits outweigh costs and that the program has led to a substantial decrease in unaccounted-for water without incurring greater repair costs for the system.

O'Day, D. K., Fox, C. M., and Huguet, G. M., "Aging Urban Water Systems: A Computerized Case Study", _Public Works_ (Aug. 1980).

A study of water main breaks in New York City showed that the frequency of breaks is increasing, small diameter mains have higher break rates than larger mains primarily due to bedding problems, pipe laid before 1870 has a high break rate, break rates increase during winter, breaks are often caused by contact with other structures, the system is not wearing out due to age, leaks are an important factor in main breaks, main breaks are caused by increased loading on the main. Wholesale pipe replacement based on the useful life of pipe is not a valid concept.

Reeves, P. J., "Accurate Flow Measurement a Necessity", _OpFlow_, (Feb. 1985).

Describes the need to meter treatment plant flow rates in order to control cost of treatment and quality of treated water, and describes different types of meters.

Reeves, P. J., and Kearns, H. J. P., "Water System Maintenance 'Record Keeping' Made Easy", _Public Works_ (Dec. 1984).

Describes nature of records which water utilities need to keep, and simple forms for keeping such records.

Sonnen, M. B., "Benefit Estimation For Quality Improvements", _Jour. AWWA_, 68:11 (Nov. 1976).

Describes a procedure for determining the benefits obtained by improving the quality of water delivered to customers. The benefits appear to be much greater than previously estimated, and less than the cost.

Van Beek, C. G. E. M., "Restoring Well Yield in the Netherlands", Jour. AWWA, 76:10 (Oct. 1984).

Describes the causes, symptoms of the causes, methods of restoring yield, and measures for preventing well clogging.

VanBeek, C. G. E. M., "Curtailing Corrosion", Jour. AWWA, 76:8 (Aug. 1984).

General discussion of the importance of controlling corrosion, and summary of articles on corrosion included in that issue.

Walski, T. M., "Selecting an Economical Water Main Rehab", Civil Engineering, 54:9 (Sept. 1984).

Describes alternative methods for removing deposits from the inside of pipes in order to restore carrying capacity.

Walski, T. M., "Assuring Accurate Model Calibration", Jour. AWWA, 77:12 (Dec. 1985).

Water distribution system models are only as good as the data with which they are calibrated. Simply comparing predicted and observed pressures during normal use cannot ensure accuracy. Some tips for calibration are presented.

Walski, T. M., "The Cost of Repairing Pipe Breaks", Public Works (Nov. 1985).

Provides methodology and data for estimating costs of repairing pipe breaks.

Walski, T. M., "Replacement Rules for Water Mains", Jour. AWWA, 79:11 (Nov. 1987).

Provides an improved rule for determining when to replace water mains because of leakage, pipe breaks, and inoperative valves.

Woodcock, C. P. N., "Small Water Systems and Their Problems", Jour. AWWA, 76:12 (Dec. 1984).

Panel discussion of small water systems, and procedures for handling their problems.

B. Rates and Rate Making

AWWA Committee on Water Rates, Water Rates Manual M1, AWWA, Denver, CO (1972).

The standard reference in the industry.

Gall, J. J. & Catlin, T. S., "Rate Structure Alternatives for Utilities", Public Works, pp.39-43 (June 1982).

Discusses some alternatives to the typical "minimum charge and declining block rate" structure for water service. Included are service charges, uniform rates, increasing block rates, and seasonal surcharges. Rate structure alternatives for sewer systems are discussed as well.

Griffin, F. P., "Policing Demand Through Pricing", Jour. AWWA, 74:6 (June 1982).

By concentrating on the peak-use season, the Fairfax County (Va.) Water Authority developed a rate structure that reduced demands and equitably charged its customers. Practical improvements were made in traditional rate schedules by approaching marginal costs on a more refined basis.

Mann, P. C., "Water Rates-An Evaluation of Options", Jour. AWWA, 69:2 (Feb. 1977).

Discusses various rate structures with regards to cost of service, efficiency, equity and feasibility. The optimum rate structure depends on the criteria imposed in the rate determination process. The selection of criteria involves value judgements.

Stanley, R. H. and Luiken, R. L., "Water Rate Studies and Rate Making Philosophy", Public Works, pp.70-73, 116, (May 1982).

Seeks rate systems that will reduce on-peak usage and/or encourage off-peak usage. Examples are worked through comparing the traditional annual rate approach with a seasonal rate system and one that includes a ratcheted commodity charge (demand charge).

Woodcock, C. P. N., "The Water Rate Tug of War: Social Vs. Structural Needs", Public Works (Feb. 1985).

Illustrates the multitude of local issues that should be considered in developing water rate schedules.

C. Computerized Record Keeping

Cesario, L., Microcomputers for Water Utilities, AWWA, Denver, CO (1986).

Hydrant Flow, Computer Software program available from AWWA, Denver, CO (1987).

Program quickly analyzes and plots flow test results, and maintains test histories of each hydrant and keeps a census of all hydrants in the system.

Skeels, J., "Electronic Data Processing for Small Systems", OpFlow, pp. 4-5 (August 1982).

Describes the automated billing and record keeping system installed by a small (135 customer) water system for about $8,000.

Wintish, J. P., "Choosing a Second Generation Computerized Billing System", Jour. AWWA, 78:5 (May 1986).

(See also advertisements for various computer software packages in industry trade and technical journals.)

D. Financing Repairs and Improvements

Vaughan, R., "Infrastructure: Money and Methods", Civil Engineering, 54:9 (Sept. 1984).

Discusses how various parts of the country are financing repair of infrastructure.

PART VII

EXAMPLES OF USEFUL RECORD KEEPING FORMS

Samples of forms that water utilities have found useful for recording various aspects of their operation are shown in the following pages. Hopefully, they will give you ideas of how to improve your record keeping. You are free to adapt and use any of the forms shown.

CH - CHAPMAN E - EDDY M - MUELLER
C - CRANE I - IOWA R - RENSSELAER
D - DARLING L - LUDLOW S - SMITH

VALVE REGISTER

SHEET NO. ______

____
COMPANY

VALVE NO.	PRINCIPAL STREET	DISTANCE			INTERSECTING STREET	DISTANCE			SKETCH NO.	MAKE	SIZE	TYPE	MAIN	LATERAL	BLOW-OFF	OPENS	TURNS	WORK ORDER NO.	DATE INST.	DATE REMOVED	REMARKS
		FT.	DIR.	REFERENCE		FT.	DIR.	REFERENCE													

FORM 372
(REV 8-1-70)

VALVES NOS. ______ TO ______

Reduced from 11" X 17" original

VALVE INSPECTION REPORT

MUNICIPALITY ______________________ VALVE NO. ____________

LOCATION ____

SIZE ____________ MAKE ____________ OPER. NUT ____________

OPENS ______________________ NO. TURNS ____________

VALVE IN ______________________ ROUTE NO. ____________

CONDITION	INSPECTION DATES					
OPENS						
NO. TURNS						
STEM						
PACKING						
NUT						
BOX OR MANHOLE						
VALVE IS NOW						
INSPECTED BY						

CONDITION	INSPECTION DATES					
OPENS						
NO. TURNS						
STEM						
PACKING						
NUT						
BOX OR MANHOLE						
VALVE IS NOW						
INSPECTED BY						

CONDITION	INSPECTION DATES					
OPENS						
NO. TURNS						
STEM						
PACKING						
NUT						
BOX OR MANHOLE						
VALVE IS NOW						
INSPECTED BY						

MONTHLY VALVE REPORT

Month: ______________________________ Year: ___________

LOCATED AND OPERATED:

Total No. Valves in System ___________

No. Operated (leak repair, etc.) During Month ___________

No. Located/Operated Per Valve Program During Month ___________

Total This Month ___________

No. Previously Operated ___________

Balance Unoperated Valves ___________

% of Valves Operated to Date ___________

VALVE BOXES RAISED/CLEANED OUT:

No.. ___________ Man Hours _________

MONTHLY VALVE REPORT

Month__________ Year______ District______________

LOCATED AND OPERATED

Total No. Valves in System ______

No. Operated (leak repair, etc.) During Month ______

No. Located/Operated Per Valve Program During Month ______

Total This Month ______

Balance ______

No. Previously Operated This Year ______

Balance Unoperated Valves ______

VALVES COULD NOT LOCATE

No.	Size	Valve #	Man Hours
____	____	____	____
____	____	____	____
____	____	____	____

VALVE BOXES RAISED/CLEANED OUT

No.____ Man Hours______

VALVES FOUND BROKEN/INOPERABLE

No.____ Size____ Valve #______ Man Hours____

Broken Open____ Closed____

No.____ Size____ Valve #______ Man Hours____

Broken Open____ Closed____

VALVE LOCATION AND OEPRATION STATISTICS

Size	Number In System	Number Located/Operated	Dates Located/Operated
2"	____	____	____
4"	____	____	____
6"	____	____	____
8"	____	____	____
10"	____	____	____
12"	____	____	____
Other			
____	____	____	____
____	____	____	____

Remarks:

Completed By: ______________ ______________
Manager

HYDRANT REGISTER

C – COREY   I – IOWA   M – MUELLER
D – DARLING   L – LUDLOW
E – EDDY   MA – MATHEWS

____
COMPANY

SHEET NO. __________

HYDRANT NO.	PRINCIPAL STREET	DISTANCE			INTERSECTING STREET	DISTANCE			SIZE	MAKE	NOZZLES		SIZE OF LATERAL	LATERAL VALVE NO.	WORK ORDER NO.	DATE INST.	DATE REMOVED	REMARKS
		FT.	DIR.	REFERENCE		FT.	DIR.	REFERENCE			$2\frac{1}{2}$"	$4\frac{1}{2}$"						

Reduced from 11" X 17" original.

Date ____________

____________ District

Hydrant Installation Work Sheet

Township ____________

Requested by ____________

Location: Map No. ____________ Quadrant ____________

Steet Name ____________

Main Size ____________

Expected Flow, GPM @ 20 PSI ____________

Static Pressure PSI ____________

Location Elevation from U.S.G.S. Ft. ____________

Nearest Hydrant Number ____________

Location Nearest Hydrant ____________

Static Pressure at Nearest Hydrant, PSI ____________

Flow at Nearest Hydrant GPM @ 20 PSI ____________

Elevation Nearest Hydrant, U.S.G.S. Ft. ____________

NOTE: If expected flow is less than 750 GPM @ 20 PSI, state what improvements are required to provide this flow. Notify authorities of the cost involved to provide this service and obtain an agreement for payment of costs. Hydrants with expected flows less than 750 GPM will not be approved for installation.

Attach a copy of this form to the Hydrant Installation Work Order.

Date ______________

______________________ District

HYDRANT FLOW REPORT

No. of hydrants in system ______________

No. of hydrants flow tested in 19____ ______________

No. of hydrants with flows below 500 GPM ______________

No. of hydrants scheduled for flushing in 19____ ______________

List all hydrants with flows less than 500 GPM

Hydrant No.	Map Location	Flow GPM	Static Pressure	Residual Pressure	Lateral Size	Main Size

HYDRANT INSPECTION REPORT

MUNICIPALITY ____________________ HYD. NO. ____________

LOCATION ____________________

MAKE ____________________ SIZE ____________

2½" NOZZLES ____________________ STEAMER NOZZLES ____________

OPENS ________ SIZE MAIN ________ SIZE BRANCH ________ BRANCH VALVE NO. ________

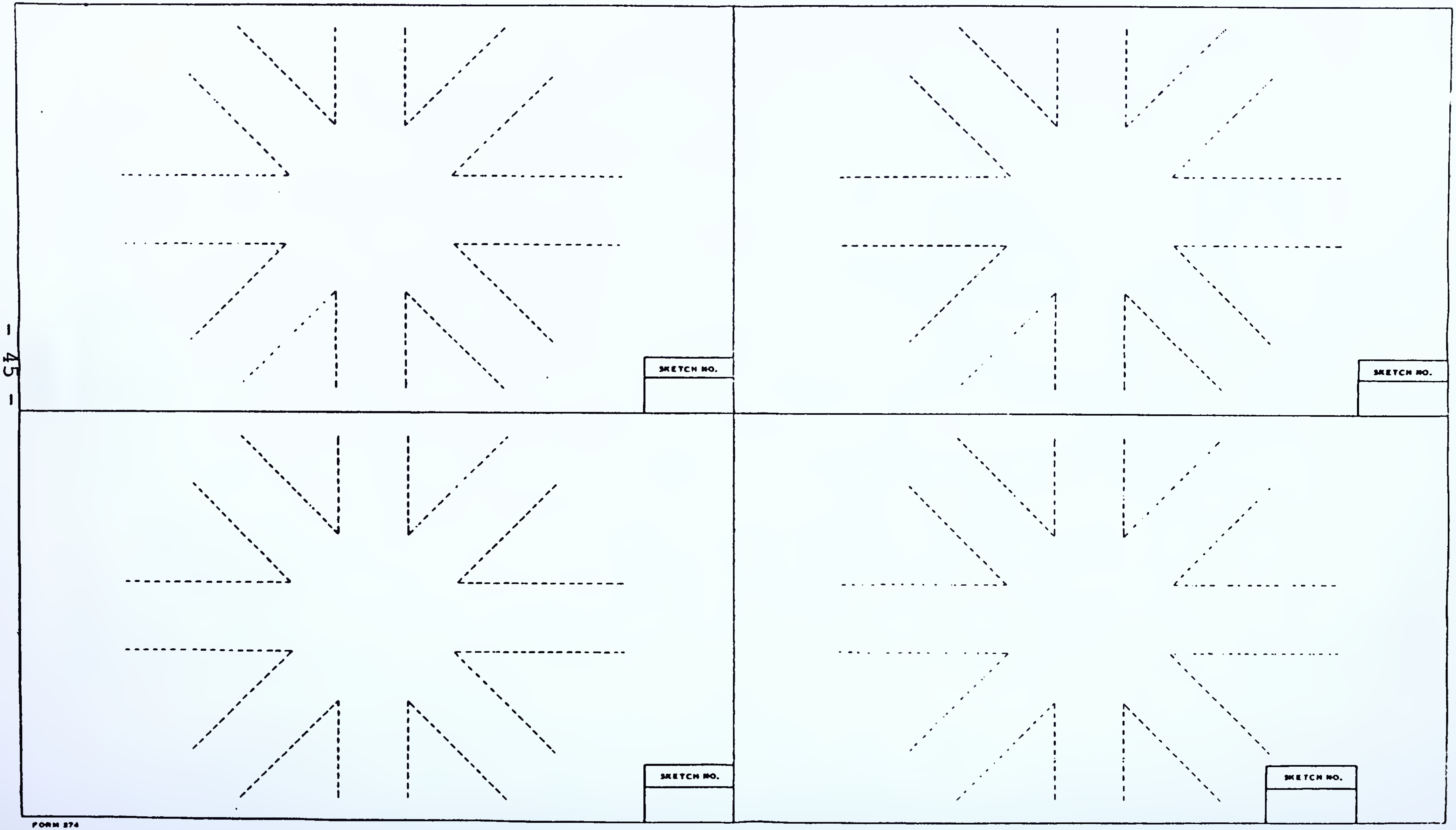
CONDITION	INSPECTION DATES					
PAINT						
CAPS						
CHAINS						
STEM						
PACKING						
DRIP						
TOP NUT						
VALVE						
VALVE SEAT						
CONDITION OF WATER						
MINUTES FLUSHED						
STATIC PRESSURE						
RESIDUAL PRESSURE						
FLOW						
INSPECTED BY						

CONDITION	INSPECTION DATES					
PAINT						
CAPS						
CHAINS						
STEM						
PACKING						
DRIP						
TOP NUT						
VALVE						
VALVE SEAT						
CONDITION OF WATER						
MINUTES FLUSHED						
STATIC PRESSURE						
RESIDUAL PRESSURE						
FLOW						
INSPECTED BY						

FORM 277

STREET INTERSECTION DRAWING

1. SKETCHES NOT TO SCALE
2. SHOW NORTH ARROW
3. INDICATE WHETHER CURB OR PROPERTY LINE



FORM 274

Reduced from 11" x 17" original.

APPENDIX I

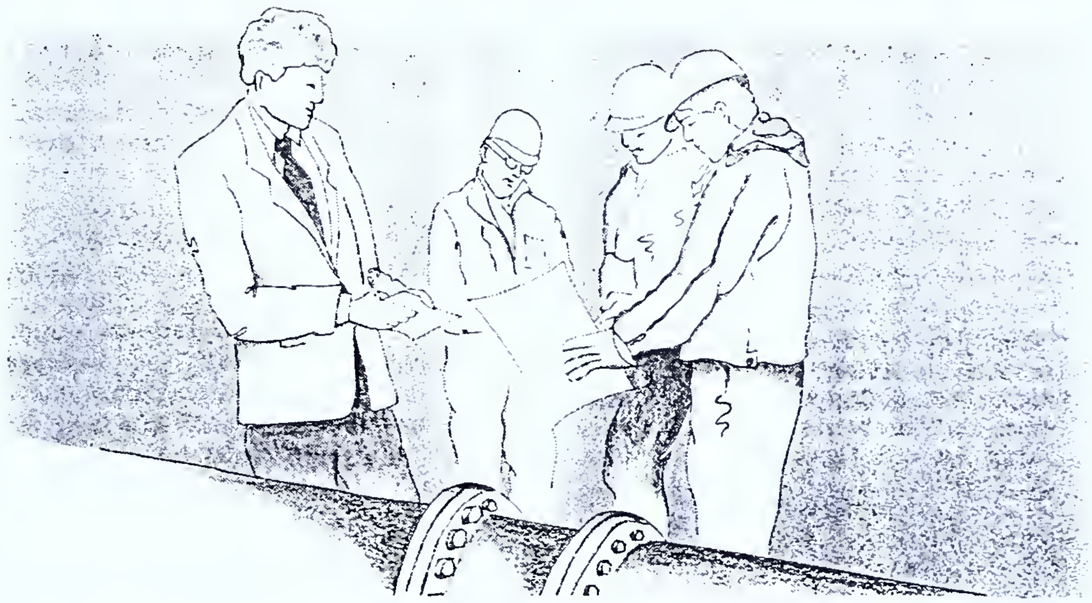
GUIDELINES FOR HIRING A CONSULTING ENGINEER

Reprinted from OpFlow, Vol. 12, No. 8, by permission.

Opflow
Vol. 12 No. 8 August 1986
ISSN 0149-8029
A monthly publication for members of the American Water Works Association

Guidelines for Hiring a Consulting Engineer

Peggy Johnson
Environmentalist/Water Supply Specialist
Dept. of Social and Health Services
Olympia, Wash.



A water system often needs the services provided by a consulting engineer.

Public water systems often need the services of a professional consulting engineer when improvements to the water system are needed. Large, privately owned systems and city or water-district systems frequently have an engineer on staff or under contract. Smaller water systems, however, often must contract with a consulting engineer as the need arises.

Selecting and contracting with an engineer may present a problem for the small system. The system's personnel may have limited or no prior experience in hiring an engineer and may not know what questions to ask or what criteria to use in the selection process.

This article is a guide for any system, small or large, that is not familiar with hiring an engineer. The guide is in a question-and-answer format. The questions presented here are the ones most likely to arise in the hiring process.

Why would a water system need to hire an engineer?

An engineer performs the following engineering services in relation to the planning, design, and construction of water systems:

- Identifying source, storage, or water distribution system problems and analyzing alternate solutions to these problems.
- Ensuring that the system designed will function properly, be efficient, and be economical.
- Preparing detailed engineering plans and specifications to implement the selected solution to the problem.
- Assisting in obtaining plan approval and obtaining bids from contractors to perform the work.
- Inspecting and testing the quality of the contractor's work and making necessary reports and recommendations to the water system.
- Completing necessary certification documents and as-built plans to the extent that the engineer has direct knowledge of the as-built facilities.
- Completing the operation and maintenance (O&M) manual and reviewing it with the system operator.

What kind of engineer is needed?

There are many categories of engineering specialties. The categories include, but are not limited to, civil, environmental, management, and sanitary. Most states require that the engineer selected must be a professional engineer (PE) licensed by that state. The engineer should also have experience with public water systems.

What is a professional engineer (PE)?

A PE is a person who has had specialized college education and engineering experience and who has been examined by and annually licensed by the state in which he or she practices.

Why must a water system hire a PE?

- There are numerous technical details involved in designing and installing a water system. Details such as friction loss, valve sizing and placement, soil conditions, and treatment alternatives require the expertise of a trained individual. A PE will have the knowledge and experience to deal with these technical details.
- Most state laws require that certain documents relating to public water systems be prepared by a PE licensed in that state. These documents are all water system plans, engineering reports, and final plans and specifications for new public water systems, extensions, and alterations. Minor pipeline extensions or replacements or other minor projects may not require such extensive engineering expertise.
- Many states also require that a certificate signed by a PE be submitted to the state following completion of and prior to use of any project approved by the state. The certificate states that the PE has inspected the project and that it has been constructed in accordance with the plans and specifications approved by the state.

How does a water system find an engineer with expertise in water systems?

There are several ways of finding engineers who may be interested and capable of providing the needed services.

(continued on page 6)

Consulting Engineer

(continued from page 1)

Common ways to find a consultant are

- Contact other small water systems to determine which engineers have provided them with satisfactory service.
- Consult directories such as those published by the Consulting Engineers Council of your state or the National Society of Professional Engineers.
- Consult the yellow pages of the telephone books for larger towns and cities. Listed under "Engineers" will be various categories of engineering specialties.
- Consult the AWWA *Buyer's Guide*, and *Journal AWWA*, which contain a professional services section.

What criteria should be considered in selecting an engineer?

The primary considerations in selecting an engineer are relevant experience in the types of services needed and demonstrated ability to serve in a timely and effective manner. The basic criteria that should be used in the selection process include

- Knowledge—The engineer should have specialized education or training in the aspect of public water system engineering that the small water system needs.
- Experience—The engineer should have professional engineering experience with similar water system projects.
- Ability to service—The engineer should demonstrate that sufficient uncommitted time and other resources are available to perform the services within the time needed by the water system.
- Communication—The engineer should demonstrate the ability to communicate in a thorough and timely manner to keep the water system fully and satisfactorily informed.
- References—The engineer should provide three or more references from previous clients for whom similar water system engineering services have been performed. In addition to a contact person, information on the type of project, year the project was undertaken, total actual versus estimated cost of the project, and name of the engineer in charge of the project should be provided.

If an engineering firm is hired, these criteria should apply not only to the engineering firm but also to the engineer who will actually be doing the work. Many large engineering firms have people who meet all these criteria but they will not actually be working on each of their client's projects.

What procedures should be used to select an engineer?

- Contact at least three engineers, briefly discuss what engineering work is needed, and find out if they are interested.
- Interview three or more of the engineers expressing an interest, based on the selection criteria previously outlined.
- Contact the references and ask how the engineer performed the assignment.
- Rank the engineers in order of preference.
- Request that the engineer ranked first submit a written proposal. The proposal should include such details as what work will be accomplished, how the work will be done, how much time it will take, what fees will be charged, and what payment method will be acceptable.
- Meet with the engineer, if necessary, to discuss any items not fully addressed in the proposal.

If the terms and conditions of a contract are mutually acceptable, let the other engineers who were interviewed know of the selection. If contract terms cannot be mutually agreed on, end negotiations with the first engineer and begin to negotiate with the second ranked engineer.

What services should the engineer perform?

There is no standard package of services that engineers perform. The services are tailored to the specific needs of each water system. However, there are generally three phases of a project that the engineer is involved in—planning and preliminary design, final design, and construction.

- Planning and preliminary design involves studying the problem, determining alternate solutions, outlining the basic concept, making preliminary cost estimates, and establishing project feasibility. The water system should not go into a project with a preconceived idea of what is needed. The engineer should not be expected to just give a seal of approval, but should actually perform the required analysis.
- Final design includes design, field work, preparation of final plans and specifications, and cost estimates, as well as submittal to and obtaining approval of all required agencies.
- Construction may involve construction stakeout, surveillance and/or inspection of the contractor's work during construction, review of contractor's progress payment requests, and other matters required to assist the system in the construction phase. Preparation of as-built drawings and completion of the as-built certification is also often included in this phase.

How are the costs of engineering services determined?

Engineering fees may be based on a set fee per day, cost times a factor, lump sum, or percentage of project cost. Details such as "Will travel time be an additional charge, and if so at what rate?" and "Will the fee include all consultation or will each meeting be an additional charge?" should be established. Whatever financial arrangements are made, the specifics of services to be performed and how they are to be reimbursed should be fully agreed on before a contract is signed.

By using this guide, the small public water system should be able to select and contract with an engineer that will satisfactorily perform the needed services when water system improvements are necessary.

1487

SUSQUEHANNA RIVER BASIN COMMISSION

DEC. 24, 1970

UNITED STATES • PENNSYLVANIA • NEW YORK • MARYLAND